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VARIATION IN SUNSHINE AT GIBRALTAR

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A standard Campbell-Stokes sunshine recorder has been in daily use at Gibraltar since 1938. Two sites (shown in Fig. 1) have been used in turn: Windmill Hill until 1947, and North Front near the Spanish border from 1948; there was no overlapping period. An enforced move of instruments of 300 yards to the south-west occurred on May 18, 1940 at Windmill Hill but examination of the records suggests no significant change in exposure characteristics; there was also a very minor change at North Front on May 1, 1955 of 100 yards to the north-east. The exposures both at Windmill Hill and North Front were very good, with uninterrupted horizons through the day in the winter and summer until the hills of Spain obscured the late evening sun.

Monthly and yearly average and extreme figures of daily sunshine are given for both stations in Table 1, together with the appropriate standard deviations.

It is obvious that there is far greater variation in winter than in summer – expected, of course, as a single winter month in the unsettled part of the year can enjoy particularly favourable, or suffer unusually adverse conditions. In summer on the other hand, even prolonged cloudy weather can only cause restricted effect on a Mediterranean-type summer climate. Thus the variation at Windmill Hill in February shows an average difference in daily sunshine of over four hours in the two years 1945 and 1947, whilst the much more sunny July shows a difference of less than two hours. The mean standard deviation for the period 1938–56 is ·70 hours or under from June to September, and is over 1·00 hours from November to April except for January when outstandingly high or low values have been unusual; in particular, January at North Front has been a month with remarkably little variation. In view of the January variation at Windmill Hill, this is thought fortuitous. Monthly sunshine averages form a frequency distribution which is closely akin to normal (except of course that it is bounded at both ends); the form of frequency distribution makes an interesting contrast with the trapezium shape of daily sunshine data.[1] The difference between the two distributions is analogous to that between yearly or monthly and daily rainfall data.

Average figures for sunshine for the two sites are shown in Fig. 2, which brings out more clearly several rather striking features; also shown in this figure are the mean monthly totals expressed as percentages of possible sunshine.

The main points of interest are the very marked difference between the two stations in November and December, and the marked deficiency of sunshine in March, especially at North Front. Agreement is fairly close from April to October, but the over-all total of sun during the year is over 120 hours less at North Front than at Windmill Hill. On the whole, the smoothness of both curves suggests that sufficiently long periods have been taken for them to be reasonably close to the truth.

TABLE I—COMPARISON BETWEEN SUNSHINE MEASURED AT WINDMILL HILL AND AT NORTH FRONT, 1938–56

	Windmill Hill (1938–47)				North Front (1948–56)			
Month	Average hours	Standard deviation of average	Highest daily average	Lowest daily average	Average hours	Standard deviation of average	Highest daily average	Lowest daily average
Jan.	5·93	·92	7·50 (44)	4·29 (47)	5·53	·38	6·34 (52)	5·09 (48)
Feb.	6·49	1·39	8·72 (45)	4·42 (47)	6·22	·60	7·37 (54)	5·61 (55)
March	7·01	·95	8·86 (39)	5·70 (43)	5·97	1·08	7·62 (52)	4·43 (53)
April	8·38	1·41	10·25 (40)	6·14 (46)	8·19	·86	9·81 (50)	6·83 (49)
May	9·89	1·10	11·08 (39)	7·51 (44)	9·84	·86	11·24 (53)	8·59 (48)
June	10·71	·87	12·01 (43)	9·67 (45)	11·17	·47	11·79 (50)	10·44 (55)
July	11·23	·65	12·17 (45)	10·23 (39)	11·30	·54	11·97 (51)	10·05 (55)
August	10·73	·68	11·75 (46)	9·19 (44)	10·57	·55	11·46 (50)	9·73 (53)
Sept.	8·59	·54	9·23 (38)	7·33 (42)	8·89	·64	10·39 (48)	8·09 (49)
Oct.	7·41	·82	8·68 (44)	6·25 (40)	6·90	·91	8·29 (51)	5·17 (53)
Nov.	6·01	1·23	7·88 (43)	4·07 (38)	4·81	1·12	6·53 (50)	3·28 (53)
Dec.	5·73	·99	7·24 (46)	3·73 (43)	4·53	1·19	6·48 (50)	3·45 (53)
Year	8·17	·27	8·53 (45)	7·57 (41)	7·83	·33	8·43 (50)	7·42 (53)

Figures in brackets give the years of occurrence of quoted highest and lowest daily averages.

The winter difference in sunshine characteristics between the two places is due to a combination of circumstances. A well known phenomenon which occurs in moist surface easterly winds is the levanter cloud forming a banner over and to the west of the Rock, of varying persistence, length and depth according to the history of the air. In summer, this cloud does not interfere with sun recordings at North Front more than at Windmill Hill as the sun's elevation is high, and cloud over the Rock does not throw shadow at North Front. In winter, however, the midday elevation of the sun is only about 30°, and there is some afternoon loss due to levanter cloud. This probably accounts largely for the persistently more sunny conditions at Windmill Hill throughout the season. November and December, the two months of relatively low sunshine at North Front (with totals 20 per cent less than at Windmill Hill) are prone to westerlies, with averages of 62 per cent and 64 per cent of winds from this quarter respectively, compared with 42 per cent in November, 53 per cent in January and 56 per cent in February. Westerly winds are often associated with cloud, either cumulus or stratocumulus in a well broken layer. Spain, five miles to the west of Gibraltar, is so placed that with winds between south-west and west cloud at 2,000–4,000 feet would be far more prone to throw shadow at North Front than at Windmill Hill to the south; this is seen in the Windmill Hill silhouette in Fig. 1.

The March minimum is probably due to the higher incidence of levanter conditions than in neighbouring months; on the average, levanter winds in

March total 43 per cent of the occasions, compared with 39 per cent and 31 per cent in February and April. Moreover, it is an unsettled transitional month with a secondary rainfall maximum, and the average cloud amount is higher than for any other month of the year (see Table II). It would therefore be expected that the percentage of sunshine in March would be lower than in February, though the actual daily average at North Front in March being less than that in February with its shorter days is surprising, as is the marked difference between North Front and Windmill Hill. The March minimum is not caused by one or two exceptional readings, because in five years out of nine at North Front and four years out of ten at Windmill Hill, the daily average for February was higher than that for March.

The closeness of accord between the two curves from April to September, the season of prolonged fine weather, is strong support for the accuracy of the mean. The only anomaly between the curves is the low value of the daily sun in June at Windmill Hill. This seems a real difference, as the two dullest Junes at the station (in 1944 and 1945) were not outstandingly dull, and their omission from the average still leaves Windmill Hill as appreciably less sunny than North Front. The most feasible explanation is that June represents the start of the really moist levanter season, with sea temperatures lower compared with air than later in the year, and that Windmill Hill itself at 400 feet suffered in this month. Interestingly June and July are almost equally bright at North Front.

A further minor factor contributing to the season differences lies in the different heights and locations of the two stations. There is of course always some uncertainty as to the elevation of the sun at which there is burn on the sunshine card, and variation can be in the range up to $4°–5°$ depending on haze conditions etc.; usually with clear skies burn occurs at Gibraltar with the sun below the generally accepted $3°$ elevation, particularly in the evening; definite measurable burns have been obtained in fairly clear air until the sun has been obscured by the Spanish hills at elevation down to about $1°$.

The silhouette of these hills as seen from North Front, at 20 feet, and Windmill Hill, at 400 feet, are shown in Fig. 1; the limits of sunset are almost exactly $240°–300°$ true, but the silhouette is continued southwards to sea level for Windmill Hill. It is seen that there is more loss of sun at North Front than at Windmill Hill, especially in winter; the summer difference is not great, but there is a gain at North Front before the vernal and after the autumnal equinoxes. Precise numerical evaluations of the effects of these height and topographical factors is impossible, but potentially there is morning advantage of almost ·025 hours at Windmill Hill due to its greater height, and the evening advantage due to skyline at Windmill Hill is ·125 hours daily in winter; there is little difference in summer, and there is slight evening equinoctial gain at North Front of ·035 hours. Allowing that clear conditions obtain with an approximate frequency of two cloudless periods out of three, and taking the winter and summer average sunshine values of 60 per cent and 75 per cent, the over-all gain at Windmill Hill from topographical sources is about 10 hours annually.

It is of interest to consider the distribution of sunshine round the Rock as a whole. Records have been kept only for the two stations discussed, but allowance may be made for other locations. At Catalan Bay in the east the sun

is cut off by the Rock at about 1400 sun time in winter, about 1515 in summer; bearing in mind that there is 10 per cent or rather more sun after noon than before, sunshine at Catalan Bay would be expected to be just under 70 per cent of that at Windmill Hill in winter, just over 70 per cent in summer, and the mean daily average 5·7 hours. On the west side, loss of sunshine is rather less as the slope of the ground is appreciably less steep; sunless conditions would last only up to about 0700 sun time in summer in the neighbourhood of the City Hall and 0900 in winter. There is, on the other hand, more loss from levanter cloud interference at this position than at other sites discussed (it is not particularly uncommon for levanter cloud over the Rock to persist for a prolonged part of the day in either summer or winter) so the percentages of sunshine at City Hall compared with those at Windmill Hill would be of the order of 80 per cent in winter and 85 to 90 per cent in summer, with a yearly average of about 85 per cent of the Windmill Hill daily mean: 6·9–7·0 hours.

No comparative data are available for the surrounding areas of Spain and Morocco, but in Table II are given the monthly cloud amounts for a number of stations in or near the Straits area.

TABLE II—AVERAGE MONTHLY AND YEARLY CLOUD AMOUNTS FOR SELECTED STATIONS IN SOUTH SPAIN AND NORTH-WEST AFRICA

Month	Gibraltar	Alicante	Granada	Malaga	Valencia	Cartagena	Oran	Cape Spartel
				oktas				
January ...	3·8	2·8	3·3	3·1	3·0	3·0	2·3	3·7
February ...	4·0	2·7	3·7	3·0	3·0	2·7	2·6	3·7
March ...	4·2	3·0	4·2	3·8	3·1	3·4	2·6	3·8
April ...	3·3	2·9	3·9	3·4	3·3	2·6	2·6	3·4
May ...	3·0	2·5	3·5	2·6	3·1	1·8	2·0	3·0
June ...	2·4	1·9	2·3	1·3	2·4	1·2	1·8	2·4
July ...	1·9	1·4	1·2	·6	2·0	1·0	1·8	1·4
August ...	2·3	1·6	1·4	1·0	2·3	1·0	1·8	1·4
September	3·3	2·5	2·9	2·2	3·0	2·4	2·1	2·6
October ...	3·7	3·0	3·6	2·8	3·1	2·9	2·5	3·3
November...	4·0	3·0	3·7	3·1	3·4	3·0	2·6	3·8
December...	3·7	3·0	3·7	3·1	3·2	2·6	2·6	3·9
Year ...	3·3	2·5	3·1	2·5	2·9	2·3	2·2	3·0

There are variations in the bases for the computation of these averages (most are based on two or three observations in the period 0900–2100 G.M.T.), but it is evident that Gibraltar is the most cloudy station in the area, and sunshine is probably lower than at any other low-level station within many miles except possibly in the Ceuta–Tangier area where cloud would often tend to lie to the south side of the station over the land and thus mask the sun. Malaga and southern Spain would for similar considerations be appreciably more sunny than the difference between the respective cloud totals would suggest.

The conclusions may be drawn that the sunniest part of Gibraltar is the southern tip, where effects of cloud (cumulus or levanter stratus) are less than elsewhere. The difference of annual totals of about 125 hours between favourably placed sites in the north and in the south of the colony underlines the difference which can arise in the records of nearby instruments, even when

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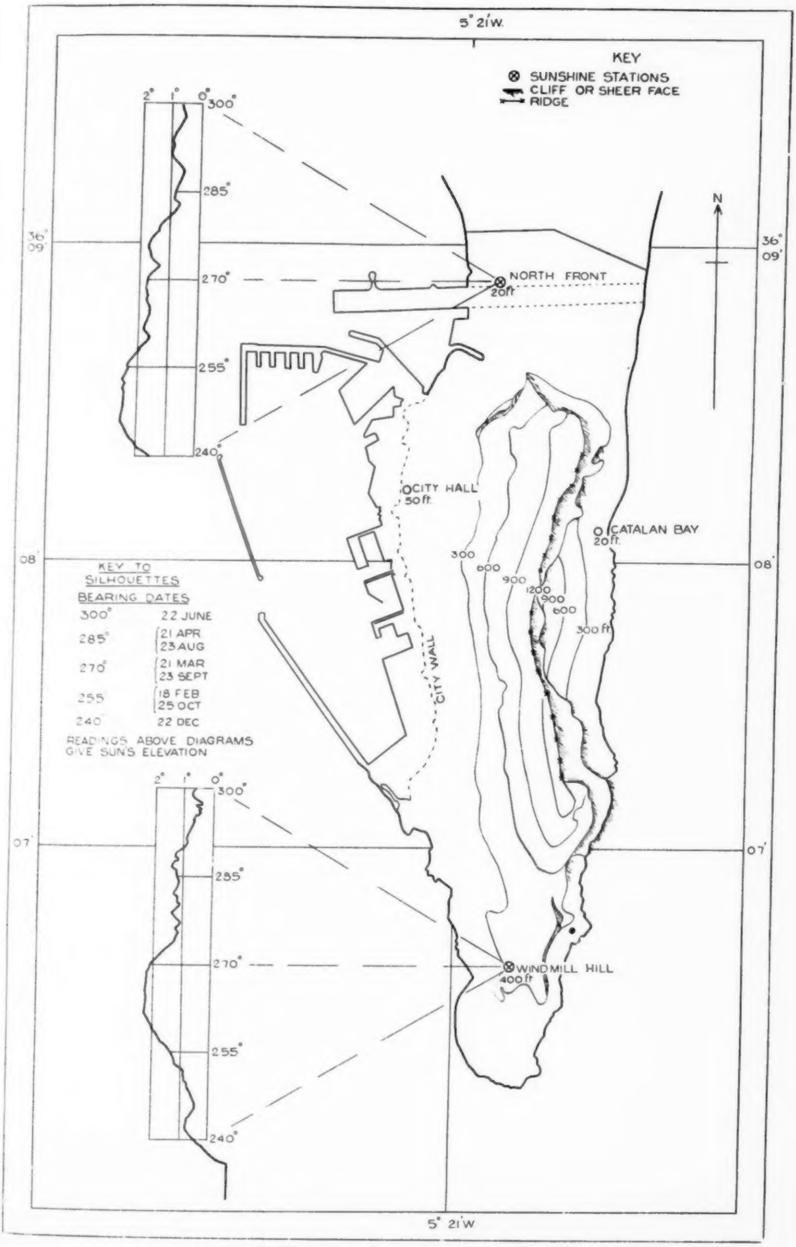

FIG. 1—GIBRALTAR: SUNSHINE STATIONS AND EXPOSURES

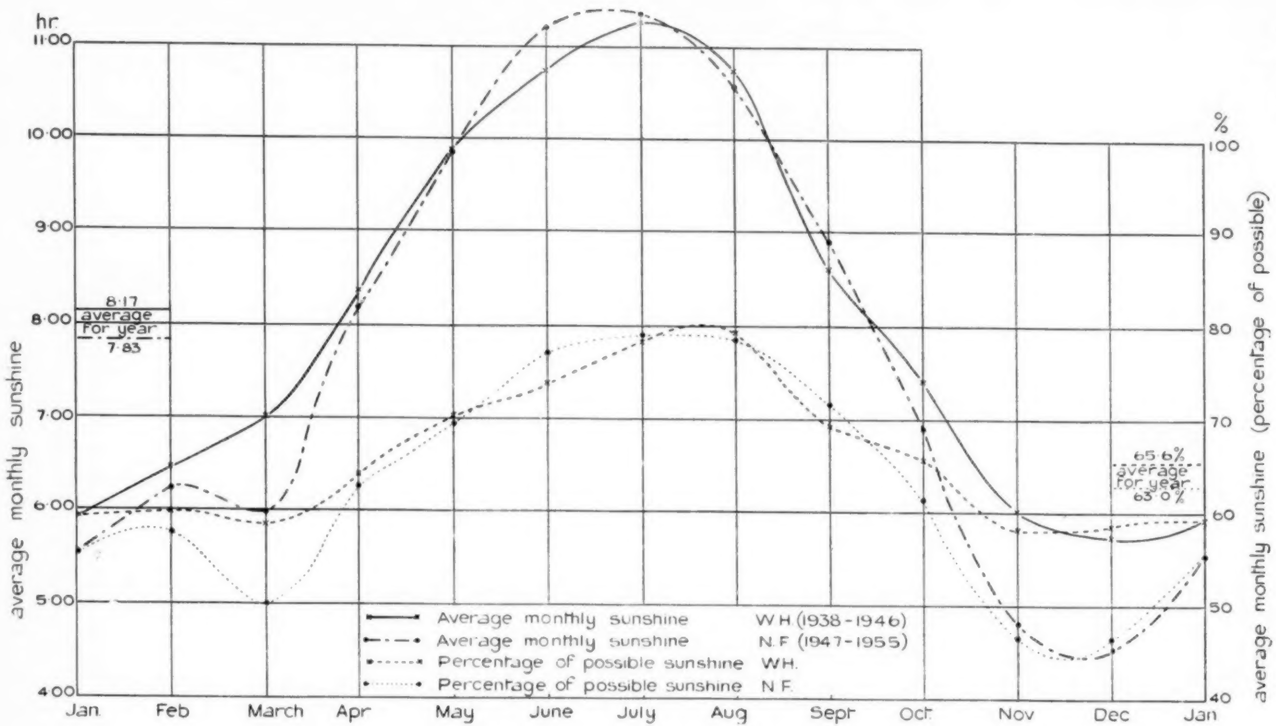

FIG. 2—COMPARATIVE SUNSHINE AT WINDMILL HILL AND NORTH FRONT, 1938–1956

superficially no great difference would be expected. Gibraltar is likely to enjoy less sun than any other coastal area in the vicinity except perhaps for certain areas on the Moroccan Coast between Tangier and Ceuta.

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AVERAGE UPPER AIR TEMPERATURES OVER ARGENTINE ISLAND

By D. DEWAR, B.Sc.

Upper air observations at stations in Antarctica for short periods have drawn attention to the greater coldness of the atmosphere in those regions compared with corresponding latitudes in the Northern Hemisphere. A British radio-sonde station was opened at Argentine Island (65°15′S., 64°16′W.) in July 1954 under the control of the Falkland Islands and Dependencies Meteorological Service; from the routine observations made since then, average monthly temperatures were computed for the period July 1954—June 1957 (Table I). For comparison with these values, average temperatures at 500 millibars and 200 millibars and average pressures at the tropopause for Stanley, Falkland Islands (51°42′S., 57°52′W.) were computed for the same period and use was made of the data readily available for two stations in similar latitudes in the Northern Hemisphere, Larkhill[1] (51°12′N., 01°48′W.) and Skattora (69°42′N., 19°02′E.). (Microfilm data for Skattora were supplied by courtesy of the Director of the Norwegian Meteorological Service.) It was not considered essential to use the same period to compare temperatures in the two hemispheres.

Data used.—As far as possible averages for Argentine Island and Stanley were computed from the daily values entered on climatological forms at these two stations; for January to June 1957, either CLIMAT TEMP[2] monthly means or values published in the Falkland Islands Daily Weather Report were used.

Prior to January 1956, British radio-sonde data were not corrected for the effects of radiation and lag on the instrument. Approximate corrections appropriate to monthly mean values were therefore applied to values for Argentine Island and Stanley for 1954 and 1955. The corrections used for Stanley are those given in *Upper air data*[3]. Sufficiently accurate corrections for the early Argentine Island data were obtained by computing radiation corrections for that station following the procedure set out in *Upper air data* and using the same lag corrections as for Stanley.

The averages for Skattora were computed for ascents made at 0300 G.M.T. but for the few occasions when these observations were missing the 1500 G.M.T. observations were substituted. For most months of the year, therefore, the observations are not liable to radiation errors; it is not known if the observations made in daylight in summer time require corrections. The average temperatures for Larkhill do not require such corrections. For Argentine Island and Stanley, the period is July 1954 to June 1957, except that for November and December 1954 there are no data for Argentine Island. For Larkhill the period is January 1946 to December 1950 and for Skattora, September 1950 to August 1954.

Average temperatures at specified pressure levels and average temperatures and pressures at the tropopause and at the surface for Argentine Island are given in Table I.

TABLE I—AVERAGES OF TEMPERATURE AND PRESSURE AT ARGENTINE ISLAND, JULY 1954 TO JUNE 1957

	Pressure (mb.)								Surface		Tropopause	
	60	100	150	200	300	500	700	850	Press.	Temp.	Press.	Temp.
	°C.								mb.	°C.	mb.	°C.
Jan.	−43	−43·4	−44·6	−45·7	−51·0	−27·8	−12·7	− 5·4	994	+0·9	277	−54·9
Feb.	−45	−45·1	−44·7	−44·7	−49·8	−31·0	−14·3	− 6·3	987	+1·0	299	−53·5
March	−51	−48·8	−47·0	−47·3	−51·3	−31·5	−15·9	− 7·3	984	−0·3	292	−55·3
Apr.	−56	−53·6	−52·4	−51·9	−51·9	−30·8	−15·1	− 7·3	989	−1·3	274	−57·7
May	−66	−61·7	−58·8	−57·7	−56·0	−32·4	−15·8	− 8·2	994	−3·0	266	−62·3
June	−72	−67·5	−64·8	−63·8	−57·9	−35·2	−19·1	−11·9	990	−7·6	257	−64·4
July	−75	−70·8	−68·7	−67·4	−58·6	−35·3	−18·7	−10·8	991	−8·7	244	−67·8
Aug.	−79	−76·0	−72·8	−70·4	−60·2	−35·8	−19·0	−12·0	994	−9·5	233	−70·2
Sept.	−75	−72·9	−72·0	−69·8	−58·8	−35·3	−19·1	−12·1	990	−8·1	235	−69·3
Oct.	−61	−63·0	−64·1	−63·7	−57·1	−34·6	−18·2	− 8·9	983	−2·5	271	−62·8
Nov.	(−49)	(−50·3)	(−52·7)	(−54·0)	(−54·6)	(−32·8)	(−17·6)	(− 9·6)	986	−1·7	(287)	(−57·7)
Dec.	(−42)	(−43·9)	(−46·1)	(−47·7)	(−53·3)	(−31·4)	(−16·5)	(− 8·7)	996	−0·0	(288)	(−55·9)
Year	−59·5	−58·1	−57·4	−57·0	−55·0	−32·8	−16·8	− 9·0	990	−3·4	269	−61·0

Values in brackets are for two years only

Comparison with other stations.—Average temperatures at 500 millibars and 200 millibars and average pressures at the tropopause throughout the year at Argentine Island, Stanley, Larkhill and Skattora are shown in Figure 1 for the periods specified above. The most interesting features shown by these graphs may be summarized as follows, temperatures at 500 millibars and 200 millibars being regarded as representative of the troposphere and lower stratosphere respectively.

Argentine Island and Skattora.—In the troposphere, temperatures are similar during the winter half of the year but Skattora becomes considerably warmer in summer, the maximum difference being a little over 10°C. The outstanding features of the graphs, however, are the differences between temperatures in the lower stratosphere and the differences between pressures at the tropopause in winter and spring. In the stratosphere in the late summer and autumn, the temperature at Argentine Island is a little above that at Skattora but during the winter and spring, the temperature at Argentine Island falls far below that at Skattora, the maximum difference being about 15°C. in spring. This coldness is accompanied by much lower pressures at the tropopause at Argentine Island than at Skattora during winter and spring. These low pressures at the tropopause at Argentine Island are not associated with high surface pressures; throughout the year the surface pressure at Argentine Island is much lower than that at Skattora.

Stanley and Larkhill.—In the troposphere, temperatures are around 5°C. warmer at Larkhill than at Stanley throughout the year. In the lower stratosphere, Larkhill is about 2°C. warmer in winter and 3°C. to 4°C. colder in summer. The tropopause at Larkhill is at a considerably lower pressure than the tropopause at Stanley for most of the year.

Larkhill—Skattora and Stanley—Argentine Island regions.—Temperatures in the lower stratosphere in these regions of the two hemispheres are much the same in autumn but not in spring. At Skattora the temperature at 200 millibars rises above that at Larkhill as early as March but it is not until a month before the summer solstice that a similar change occurs in the Southern Hemisphere. It is interesting to note that temperatures at all four stations are almost identical in the late autumn.

Variation of temperature with height in midsummer and midwinter months.—The temperature variation with height at the four stations in midsummer and mid-

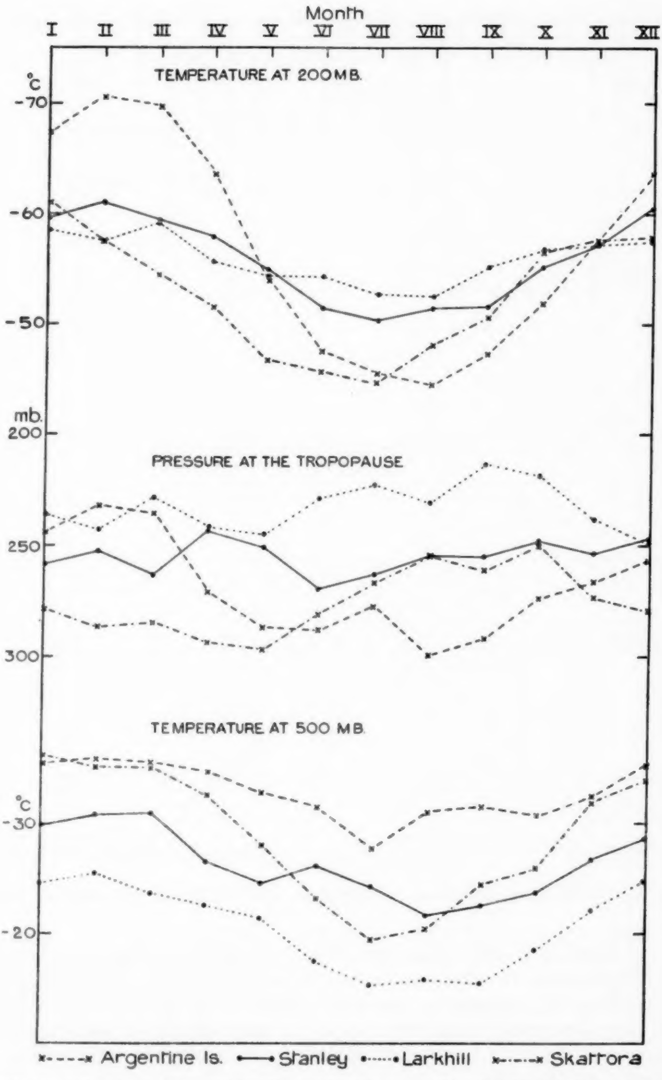

FIGURE I—AVERAGE TEMPERATURES AT 500 MILLIBARS AND 200 MILLIBARS; AVERAGE PRESSURES AT THE TROPOPAUSE

Month I is January for Larkhill and Skattora, July for Stanley and Argentine Island, etc.

winter months is shown in Figures 2 and 3. The range of average temperature from January to July at the different stations is interesting. In the troposphere, Stanley and Argentine Island show roughly the same temperature range; at Larkhill it is somewhat larger and at Skattora it is nearly double that at the two Southern Hemisphere stations. In the lower stratosphere, however, the

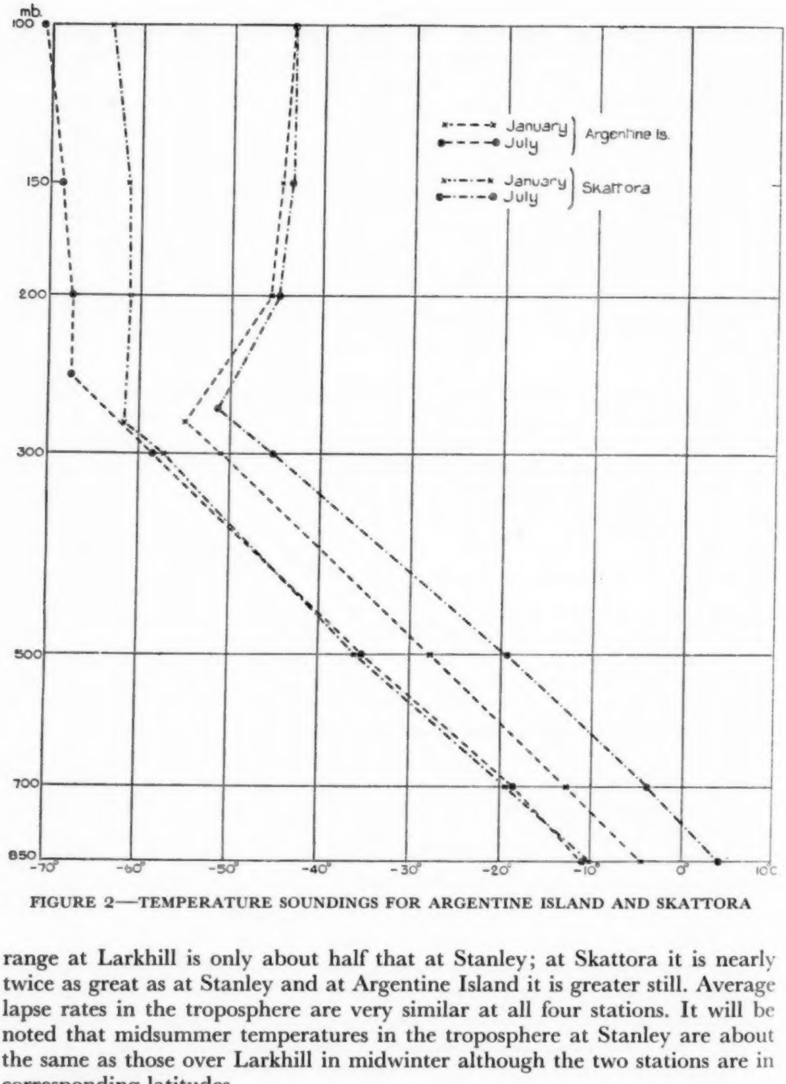

FIGURE 2—TEMPERATURE SOUNDINGS FOR ARGENTINE ISLAND AND SKATTORA

range at Larkhill is only about half that at Stanley; at Skattora it is nearly twice as great as at Stanley and at Argentine Island it is greater still. Average lapse rates in the troposphere are very similar at all four stations. It will be noted that midsummer temperatures in the troposphere at Stanley are about the same as those over Larkhill in midwinter although the two stations are in corresponding latitudes.

Extreme temperatures.—Extreme low temperatures during the three winter months (December, January, February at Skattora and July, August, September at Argentine Island) were extracted from the daily values. The lowest temperatures recorded at Skattora were −76°C. on one occasion (January 1952, at the tropopause where the pressure was 180 millibars) and −75°C. on three other occasions. At Argentine Island the lowest temperature recorded was −91°C. (August 1955 at 90 millibars) with a second lowest

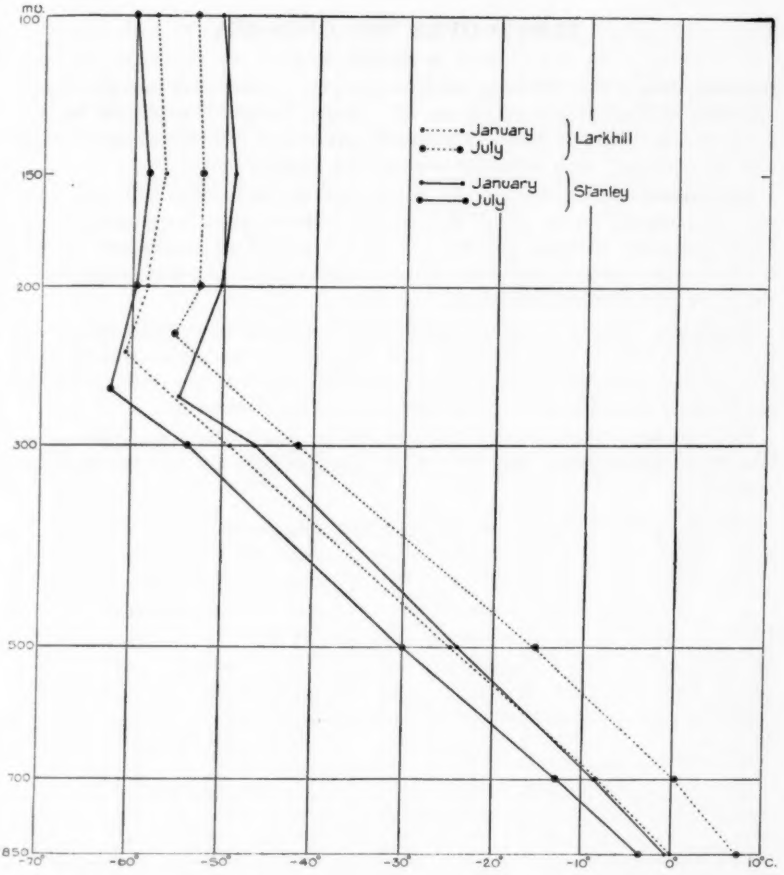

FIGURE 3—TEMPERATURE SOUNDINGS FOR LARKHILL AND STANLEY

temperature of −88°C. (September 1955 at 100 millibars). The application of an estimated radiation correction of −2°C. to the Argentine Island values gives extremes of −93°C. and −90°C. respectively. The minimum of −93°C. recorded during this short period of three years is lower than the extreme of −91°C. recorded at Batavia and regarded for many years as a world record. Other extreme values known to have been recorded during recent years are an isolated value of −97°C. at 100 millibars at Veraval (India) and −94°C. also at 100 millibars at Colombo (Ceylon), during the period 1944–1950.

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CLOUD OVER THE OPEN SEA

By F. A. SHARP, B.Sc.

Introduction.—The following note describes an investigation into the diurnal variation of cloud over the open sea. It is found that this is negligible but that in the region discussed there is a seasonal variation of total cloud which might well be associated with an upper tropospheric easterly jet.

Data used.—The data were abstracted from the 0000, 0600 and 1200 G.M.T. surface charts drawn at Changi during 1955. Ships reports were used between Ceylon and the northern tip of Sumatra but extending northwards towards the Bay of Bengal and southwards towards the Equator. All ships used were in the open sea well away from land.

Analysis.—The observations are daylight ones and should therefore give a reliable estimate of cloud amounts. The 0000 G.M.T. observation over the sea is about dawn, the 0600 G.M.T. is midday and the 1200 G.M.T. is dusk. If there is any diurnal variation then these observations should reveal it.

Low cloud.—Table I below gives month by month the average amount of low cloud at 0000, 0600 and 1200 G.M.T. together with the number of reports used.

TABLE I—AVERAGE AMOUNT OF LOW CLOUD

	0000 G.M.T.	No. of obs.	0600 G.M.T.	No. of obs.	1200 G.M.T.	No. of obs.
	oktas		*oktas*		*oktas*	
Jan.	3·4	78	3·2	95	3·1	70
Feb.	2·7	71	2·8	73	2·8	75
March	2·5	105	2·5	106	2·8	97
Apr.	3·3	97	3·1	99	2·7	96
May	4·0	103	3·3	115	3·8	107
June	3·7	115	3·3	113	3·3	113
July	3·5	112	3·4	112	3·6	111
Aug.	3·3	105	3·3	108	3·5	109
Sept.	3·5	107	3·0	93	3·6	111
Oct.	3·6	111	4·0	105	3·8	100
Nov.	4·2	108	3·9	109	3·9	107
Dec.	3·3	107	3·2	98	3·5	108
All Year	3·4	1219	3·3	1226	3·4	1204

This reveals very clearly that there is no significant diurnal variation of low cloud. The amounts of low cloud are surprisingly small; there is a slight peak in May (3·7 oktas) and November (4·0 oktas) with the south-west monsoon season June–October (3·5 oktas) slightly cloudier than the north-east monsoon, December–April (3·0 oktas); but the over-all picture is that there is not a great deal of low cloud in the area and very little variation both during the day and throughout the year.

It would be a fair inference to suggest that at all times of the year over this vast area convergence is limited to a small fraction of the area. Some indication of this might be found by studying the cumulonimbus over the area and this is important from a practical forecasting point of view. There were 3,649 reports of low cloud throughout the year. Of these only 118 reported cumulonimbus. Table II gives a distribution of these 118 cases.

In only 48 cases out of 3,649 (1·3 per cent.) could the sky be said to be well covered with cumulonimbus. It is thus much less frequent than might have

been expected. The infrequency supports what was said earlier; that in this very extensive area low-level convergence is very much the exception rather than the rule. An interesting feature was that in February and March together only six cases of cumulonimbus were reported but that otherwise over the whole year cumulonimbus occurred with almost constant frequency.

TABLE II—FREQUENCY DISTRIBUTION OF AMOUNT OF CUMULONIMBUS WHEN THAT TYPE IS OBSERVED

Oktas	No. of cases
1	2
2	15
3	18
4	15
5	20
6	19
7	11
8	18
Total	118

Before leaving low cloud an important corollary to the lack of diurnal variation should be noted. The figures reveal very clearly that there is no diurnal variation over the open sea. It follows that any diurnal variation noted elsewhere must be caused by adjacent land masses. Thus the well-known build-up of low cloud over the Straits of Malacca which is found there on most mornings must be attributed to the adjacent land masses. This corollary should be of wide application and need not be limited to the area discussed.

Total cloud.—Table III gives the average amount of total cloud month by month. There is no way of knowing how much medium and how much upper cloud is present. But having shown that there is very little variation in low cloud throughout the year it is thought that variation in total cloud is probably variation in the amount of cirrus.

TABLE III—AVERAGE AMOUNT OF TOTAL CLOUD

	0000 G.M.T.	0600 G.M.T.	1200 G.M.T.	All times
		Oktas		
Jan.	5·2	4·7	4·7	4·9
Feb.	4·3	4·7	5·1	4·7
March	3·5	3·7	4·2	3·8
Apr.	4·6	4·8	4·9	4·8
May	6·3	5·4	6·0	5·9
June	5·9	5·5	6·0	5·8
July	5·4	5·3	5·4	5·4
Aug.	6·0	5·7	6·1	5·9
Sept.	5·5	5·3	6·1	5·6
Oct.	6·1	5·8	6·1	6·0
Nov.	5·9	5·7	6·0	5·9
Dec.	4·6	4·7	5·2	4·8
Year	5·3	5·1	5·5	5·3

There is thus very little evidence for diurnal variation. However, from May to November inclusive, that is, during the south-west monsoon there is very nearly a six-okta average total cover of which 3–4 oktas is low cloud. It is thought that at this time of the year in addition to the low cloud there is usually at least 5 to 6 oktas of cirrus making up the reported average of 6 oktas total cloud.

In fact during May to November nearly one third of all observations give 8 oktas of total cloud and extensive cirrus sheets may well be very common. These cirrus sheets could be associated with the easterly jet discussed by Koteswaram[1] which he found extending along 15°N. latitude during this season.

Summary.—

(i) There is no diurnal variation of cloud over the open sea.

(ii) Any diurnal variation observed over water masses must be due to adjacent land.

(iii) Over the area discussed the low-level flow is very largely non-convergent. Convergent low-level air flow is very much the exception or when it does occur it affects a very limited area.

(iv) Cumulonimbus over the area is a rarity.

(v) Extensive cirrus sheets during the south-west monsoon may be associated with an easterly jet stream.

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ON THE PRESENT CLIMATIC FLUCTUATION

By G. S. CALLENDAR

During the last few years much has been said and written about the present climatic fluctuation, and valuable summaries of its extent in various countries have been presented by Ahlmann, Lysgaard, Scherhag, and others[1-3]. Wexler[4] suggests that the rising trend of temperatures observed in many regions may be due to better atmospheric transparency for solar heat, owing to a reduction of volcanic activity in recent decades. Plass[5] and Callendar[6] have attributed this rising trend to back radiation from the carbon dioxide produced by full combustion. Others suggest variations of solar activity, or the chance result of perturbations in the general circulation. However, a great deal of confusion has arisen as to what the term "present climatic fluctuation" actually means, and in the following an attempt is made to show how this uncertainty has come about.

Only temperature trends are considered here because these are thought to be the most fundamental expression of climatic change, although, as Kraus[7] has pointed out, precipitation may be the more convenient indicator in some tropical and subtropical climates. The figures shown and discussed on the following pages are intended to illustrate the essential difference between the local fluctuations given by decadal averages (Figure 1) and long period trends over wide areas (Figure 2). Faegri[8] has aptly stated the importance of the time factor in climatic fluctuations when he wrote: "The longer the duration of a fluctuation the greater the area within which it is felt in the same way".

Only a few temperature records are used here, and the work of Kraus[9], Willett[10], Lysgaard[2], and Callendar[11], should be consulted for world-wide climatic trends.

Discussion of figures.—Figure 1 shows the decadal temperature fluctuations at three stations covering a fairly wide range of climate. From the upper two curves for Stornoway (58°N. 6°W.) and Kew it will be seen that even within the restricted area of Britain there may be quite a long interval between the dates when these fluctuations reach a maximum. Thus 1931–40 was the warmest decade in the extreme north-west, whereas it was not until 1943–52 in the south-east.

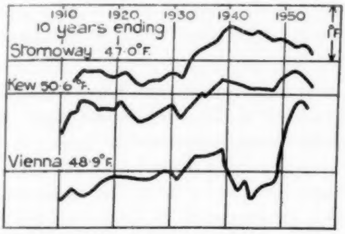

FIGURE 1.- DECADAL AVERAGES, SHOWING LOCAL TEMPERATURE FLUCTUATIONS

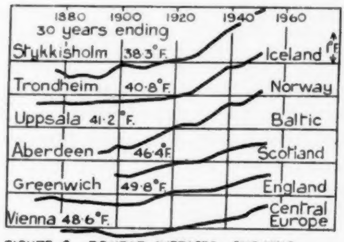

FIGURE 2.- 30-YEAR AVERAGES, SHOWING REGIONAL TEMPERATURE TRENDS

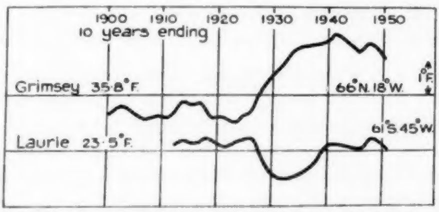

FIGURE 3.- CONTRASTING DECADAL AVERAGES, FROM THE FAR NORTH AND SOUTH ATLANTIC OCEANS

As regards the significance of this fluctuation, it may be noted that Professor Manley's researches on British temperature variations[12] indicate that we should have to go back to 1730–39 in order to find a decade as warm as 1943–52 in England. Naturally there is some uncertainty about the exact relationship of such early values to modern temperature standards, but Manley's researches, and those by Hesselberg and Birkeland[13] in Norway, make it very probable that recent averages in west Europe have been the highest for at least two centuries, perhaps much longer.

The lower curve of Figure 1 is of interest as showing the effect of the abnormally cold war years, 1940, 1941 and 1942, in central Europe, which knocked the decadal average right back to nineteenth century values for a short time, and makes the curve look very different from those at west coast stations. Subsequently, averages at the Höhe Warte observatory[14] have exceeded all previous values by a substantial amount. Here it is of interest to note that these three years 1940–42 (which were also very cold in south Scandinavia) do not seem to have caused any appreciable slowing down of the general retreat rate of Norwegian or Alpine glaciers[15].

A comparison of Figures 1 and 2 lends strong support to Faegri's maxim quoted above, for it will be seen that the temperature trend curves of Figure 2 show good qualitative agreement over a vast area, including much of Europe

and the north-eastern Atlantic. All the records used here have been closely compared back to the 1860's or 1870's, with more than one independent series from the respective countries, and are considered to be reliable and free from "urban effects". However, it has not been thought advisable to carry these curves back beyond about a century because of the lack of reliable comparative material, and the serious danger that errors in reduction to modern standards may equal, or even exceed, any real trend. In this connexion it appears from Manley's work, mentioned above, that there was no over-all trend in English temperatures during the nineteenth century. On the other hand there is much evidence that the cold season was somewhat longer and more severe in the Baltic countries before about 1882[16].

Amongst the curves shown in Figure 2 that for Stykkisholm, west Iceland[17], has the largest range of thirty-year averages with $2\frac{1}{2}$°F., Vienna the least with 0·9°F. In Britain this range increases slightly towards the north, from 1°F. at Greenwich to 1·2°F. at Aberdeen. In all cases the latest dates* give the highest thirty-year average, but the British curves are already running flat again now, as they were in the 1920's and the others may be expected to flatten off soon as the warm 1930's drop out. Turning to the nineteenth-century values, it will be seen that the early averages at Uppsala appear low in relation to the others. This is the result of the aforementioned cold seasons on the Baltic, at a period (*circa* 1857–77) when summers further south were decidedly warm.

It should be mentioned that the highest thirty-year averages recorded in the nineteenth century at the Vienna, Greenwich and Trondheim observatories, were not exceeded by a significant amount until those ending about 1930. This fact could be interpreted to mean that the "present climatic fluctuation" is a phenomena of the twentieth century. However, it is known that the glaciers of many regions had been retreating for a long time before 1900, some before 1800, and the general picture is one of a slow amelioration of climate, with many setbacks, which commenced about the middle of the eighteenth century in some regions (Alaska, Norway and New Zealand) and has been followed by a pronounced quickening in the last three or four decades. The curves of Figure 2 are representative of the latter in the North Atlantic region.

The reasons for including Figure 3 are firstly that it shows how much the decadal temperature averages can differ in widely separated regions, and secondly that Laurie Island, South Orkneys[18], is perhaps the most important single climatological station in the whole world, for it supplies the only continuous long record for the Antarctic zone—a region of special interest this year. Figure 3 compares the Laurie decadal averages with those from Grimsey (a small island some 40 kilometres north of Iceland) and it will be observed that a great oscillation occurred in the late 1920's, between the far north and south of the Atlantic Ocean. This amounted to $4\frac{1}{2}$°F. over the years 1927 to 1930 inclusive.

The Laurie temperature averages reveal a point of considerable interest to the matters discussed here, for they are virtually flat over-all during the period, with the twenty years 1909–28 exactly equal to 1931–50. This is an unusual feature, and most probably due to the strongly thermostatic control on surface temperatures exercised by the vast areas (10 to 20 million square kilometres) of

* Greenwich and Aberdeen closed about 1950. They have been continued to latest date from nearby overlapping records.

melting pack ice in these southern latitudes. Such an interpretation is supported by the observed reactions of glaciers to north of the ice (*Journal of Glaciology* and other sources). For example, retreat appears to be less marked amongst the glaciers of South Georgia, 55°S. than by those from the Hielo Continental, 50°S., and both less than in the New Zealand Alps, 44°S., or the Cordillera de los Andes about 33°S.

On the Antarctic continent itself temperatures are too much below freezing at all seasons for small changes to have an observable effect on the ice thickness in a few decades. Moreover, what evidence there is from vertical temperature profiles in the firn[19], points to stable averages for a long time, and it would appear that the "present climatic fluctuation" has so far failed to penetrate the thermal barrier of melting pack ice which protects the great southern ice cap. If any positive influence has reached the latter, by way of advection at higher levels or directly from radiative changes, it is evidently too small to be observed as yet.

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METEOROLOGICAL RESEARCH COMMITTEE

Synoptic and Dynamical Subcommittee

At the meeting on 9 October the report on progress (March–August, 1957) was reviewed and activities in the field of world climatology were noted. Features of the analysis of temperature and humidity data obtained from 1950 to 1955 in high altitude flights by the Meteorological Research Flight (M.R.P. 1052)

were discussed. This paper is a continuation of *Geophysical Memoir* No. 88. The conclusions reached in the second paper from consideration of the detailed measurements of temperature and humidity obtained by the Meteorological Research Flight in the vicinity of stratocumulus cloud were noted as an important contribution to the problem of the maintenance and dispersal of this type of cloud, and as opening the way for further investigation, for example, on the mechanism of the mixing processes in the shallow turbulent layer in the temperature inversion immediately above the cloud top. The complexity of the long-standing question of adequate methods of checking the accuracy of forecasts, of different types and for different classes of user, was recognized in the discussion of the critical survey of the subject presented in the third paper.

ABSTRACTS

TUCKER, G. B.; An analysis of humidity measurements in the upper troposphere and lower stratosphere over Southern England. *Met. Res. Pap., London,* No. 1052. 399 high altitude ascents measuring temperature and frost-point, made by aircraft of the Meteorological Research Flight, were analysed and the results compared with previous conclusions. The extreme dryness of the stratosphere is a feature of all seasons, but summer is the most moist season (in terms of water content) in the stratosphere as well as in the troposphere. Above about 500 millibars the humidity mixing ratio lapse decreases with height, and above 150 millibars the humidity mixing ratio levels out to about ·002 grammes per kilogram. The tropopause does not coincide with any marked discontinuity in frost-point or humidity mixing ratio. A graphical method is devised to show the inter-relationships between season and the temperature, frost-point and pressure at the tropopause.

JAMES, D. G.; Observations from aircraft of temperatures and humidities near stratocumulus cloud. *Met Res. Pap., London,* No. 1055. Flights by aircraft of the Meteorological Research Flight near extensive layers of stratocumulus cloud beneath dry-type inversions suggest that the cloud is in a delicate state of balance with its environment. A rate of subsidence is suggested which is sufficient to maintain the profiles of both temperature and humidity above the cloud. Evaluation of the heat and water-vapour budgets of the cloud show that a nocturnal increase in the turbulent mixing at cloud top is required to dissipate the cloud sheet.

JOHNSON, D. H.; Forecast verification: a critical survey of the literature. *Met. Res. Pap., London,* No. 1056. Investigation of many proposed forecast verification techniques shows that methods are available which meet most of the likely contingencies. When fresh systems must be devised there exists a body of experience which should enable potential pitfalls to be avoided. An appendix discusses the conditions under which rigorous tests of the statistical significance of verification scores are possible at present.

Physical Subcommittee

At the meeting on 23 October 1957 the progress report from March to August 1957 was considered and four papers were discussed. The close agreement between values (about –82°C.) of frost-point at a height of 48,000 feet over North Africa and England (M.R.P. 1024) and the similar values found at correspond-

ing heights in latitudes of Iceland and over Australia suggested the need for measurement of frost-point at high levels in the tropics proper. The use of a moving tape of thin aluminium foil (M.R.P. 1050) to obtain records in flight of cloud particles of diameter down to 80 or 100 microns was welcomed as a valuable adjunct to investigations of cloud and precipitation processes; and the preliminary results, obtained by the Meteorological Research Flight, on the distribution of drops and other particles in different types of cloud suggested the probable need for some revision of ideas on cloud processes. In the discussion of the analysis of the, probably unique, detailed measurements of humidity and temperature made by the Meteorological Research Flight in the vicinity of stratocumulus cloud (M.R.P. 1055) it was suggested that similar measurements on further occasions would be desirable for comparison with the data already obtained. The Subcommittee noted the skill with which in the fourth paper data from geostrophic air trajectories, constant-level ballon tracks and smoke-puff observations had been used to examine the applicability of an empirical exponential law and power law in the representation of horizontal diffusion in the atmosphere.

ABSTRACTS

HELLIWELL, N. C., and MACKENZIE, J. K.; Observations of humidity, temperature and wind at Idris, 23 May–2 June 1956. *Met Res. Pap., London*, No. 1024. Seventeen flights were made between 23 May and 2 June 1956 to investigate the humidity of the atmosphere at altitudes over North Africa. Ascents were made over Idris in Tripolitania in which frost-point, temperature and wind were measured at selected levels up to 48,000 feet. The mean frost-points were higher than those found over southern England except at 48,000 feet where the mean value (−82·6°C.) is nearly the same as that found in 1955 and 1956 over Britain (−82·0°C.). Three flights were made to the south of Idris reaching about 23°N. The out-bound legs were flown at constant height (35,000 feet or 40,000 feet and a cruise climb from 45,000 feet to 48,000 feet was flown on the return. These flights are treated synoptically and show that the variation of frost-point with latitude is rather small on these occasions.

GARROD, M. P.; Recent developments in the measurement of precipitation elements from aircraft. *Met. Res. Pap., London*, No. 1050. Two techniques of measuring precipitation from an aircraft are described. Initial investigations were made using sooted screens or plates, but a new method utilizing aluminium foil was found to be more practical. The results of calibrations of both techniques are presented. Some examples of snow and rain concentrations in frontal and shower clouds are included, and also numbers of drops greater than 100 microns in cumulus and stratocumulus clouds.

JAMES, D. G.; Observations from aircraft of temperature and humidities near stratocumulus cloud. *Met Res. Pap., London*, No. 1055. (see p. 208).

DURST, C. S., CROSSLEY, A. F., and DAVIS, N. E. Horizontal diffusion in the atmosphere in the light of air trajectories. *Met. Res. Pap., London*, No. 1058. The dispersion is examined of points reached after various times by geostrophic trajectories which originated at a fixed point; also the correlation coefficients are formed between the winds at that fixed point and those on the trajectories after various times. These correlation coefficients are found to obey approxi-

mately an exponential law, $r(t) = e^{-\alpha t}$. On the other hand if a relationship is sought between the scatter of the end points and their mean distance from the point of initiation, it is found that there is a close approximation to a power law of that mean distance. In the course of the calculations is it found that the value of α is dependant on $\frac{\sigma^2}{k}$ where σ is the standard vector deviation of wind and k is the coefficient of eddy viscosity for lateral mixing.

Synoptic and Dynamical Subcommittee

A fairly wide range of topics received attention at the meeting held on 13 November 1957. The first paper indicated the improvement, in the numerical prediction of a rapidly deepening small depression, which resulted from modifying the two-parameter model technique by taking into account the effect of latent heat released in the rain area, by reducing the size of the computational grid-mesh and by making some allowance for non-geostrophic motion. The next topic considered was the temperature and humidity distribution in and near frontal zones as shown by observations made by the Meteorological Research Flight in traverses at 600 millibars and 500 millibars through a number of fronts (M.R.P. 1064). A remarkable feature is the dryness of the air in the neighbourhood of fronts on a high proportion of the occasions, thus indicating the effects of subsidence of the air. The paper suggests that the temperature and humidity distributions observed are consistent with the effects of subsidence on the cold side of a jet stream. The field of view widened in the consideration of the third paper which assembles evidence on the predominance of the westerly circulation in the southern hemisphere over that in the northern hemisphere throughout most of the year, and discusses the features and probable courses of the mean ridges and troughs of the 500-millibar contour pattern in the southern hemisphere, and possible effects elsewhere in the world of changes in the southern hemisphere circulation system. The fourth paper, also near-global in scope, indicated a further stage in the assembly by the Meteorological Office of revised information on upper winds over the world. The marked difference, between the northern and southern hemisphere, in the air-flow pattern at the 100-millibar level was noted.

Recent work on the forecasting of the motion of fronts was also discussed.

ABSTRACTS

SAWYER, J. S.; Two parameter techniques of numerical forecasting applied to a small intense depression. *Met. Res. Pap., London*, No. 1063. Numerical calculations of the changes in the 1000- and 500-millibar contours on 28–29 July 1956 failed to indicate the very rapid deeping of a depression off south-west England when the methods previously used by F. H. Bushby and M. K. Hinds (*Quart. J. R. met. Soc., London*, **80,** 1954, p. 165) were applied. The calculations indicated more rapid deepening when (*a*) the static stability was treated as neutral in an area of about 100 miles extent known to be an area of heavy rain (*b*) the computational grid was given a finer mesh of 75 miles and (*c*) the "balance equation" was used to determine an initial stream function in place of the geopotential.

SAWYER, J. S.; Temperature, humidity and cloud near fronts in the middle and upper troposphere. *Met. Res. Pap., London*, No. 1064. The Meteorological

Research Flight of the Meteorological Office has made a number of exploratory flights through fronts beneath the jet stream. They confirm that a narrow "frontal zone", some 30 to 50 miles wide with sharp boundaries is often present at the 500-millibar level. On other occasions the temperature changes are more diffuse. The air in and near the "frontal zone" is usually very dry and must have undergone subsidence.

At 600 millibars the temperature gradients at fronts are somewhat less well defined than at 500 millibars, and, although dry subsided air is often found in the frontal zone, the air on the warm side of the frontal zone is usually relatively moist. Cloud occurs in this region but the boundary of the cloud appears to slope more steeply than the front itself.

Dynamical considerations suggest that the very strong temperature gradient of the frontal zone at 500 millibars arises from the differential subsidence of air on the cold side of the jet stream which leads to a tilting of the isentropic surfaces. The front-forming processes in the upper troposphere operate only where the jet stream is intensifying or becoming more cyclonically curved along its length, but the characteristic structure is carried forward into other weaker sections of the jet stream without degenerating completely.

LAMB, H. H.; The southern circumpolar westerlies, broad characteristics and apparent associations. *Met. Res. Pap., London*, No. 1065. 500-millibar topography over the southern hemisphere is studied principally by means of seasonal and yearly averages of data published in *Notos* (Pretoria). There are great differences from the trough–ridge system of upper westerlies in the northern hemisphere. The pattern is verified by reference to various observable climatic and glaciological associations. The southern westerlies are found to carry much more momentum than their northern counterparts, the ratio being 1·5 or more for the year and 4 in the northern summer. Anomalies and secular changes of the powerful southern circulation probably disturb the circulation over the rest of the world.

HEASTIE, H.; Average height of the standard isobaric surfaces over the temperate and tropical regions in July. *Met. Res. Pap., London*, No. 1066. Average heights of standard isobaric surfaces in January were given in M.R.P. 1045. Those for July follow the same lines; contour heights (in decametres) are given on Mercator charts from 75°N. to 60°S. for 700-, 500-, 300-, 200-, 150- and 100-millibar and intervening thicknesses. A brief discussion of the charts is included.

NOTES AND NEWS

Long-lived whirlwind on a mountain ridge

We are indebted to Mr. F. H. W. Green, The Nature Conservancy, for the following report of an unusual observation by Dr. D. N. McVean of the Conservancy's scientific staff:

"On August 3, 1957, I was traversing the ridge running north from Aonach Beag to Aonach Mor just east of Ben Nevis. The day was bright and sunny with an occasional light breeze from the east. At point 27/194719 (3,650 ft. O.D.) at about 1.30 p.m. my attention was caught by a whistling sound and I observed a patch of mat grass on the crest of the ridge being violently agitated.

The area of disturbance, which was about three metres in diameter, shifted slowly about on the main ridge keeping close to the angle formed by the spur ridge from the north-east. I was able to stand within a few feet of the whirlwind and feel only the faintest draught of air; on stepping into it I had the flap of my rucksack which was weighted with wallet, loose change and keys lifted over my head by the updraught.

Returning along the ridge about two hours later I was interested to see that the whirlwind continued to circle the same area although the intensity seemed to be slightly reduced."

On the day in question an anticyclone was centred over the North Sea between north-east Scotland and Holland. Over Scotland there was little cloud and the upper air winds at the height of Ben Nevis were about 5 knots from between 140° and 160°.

Averages of rainfall 1916–1950

Hitherto the standard 35-year period for averages of rainfall in Great Britain and Northern Ireland has been 1881–1915. Averages for a new 35-year period, 1916–1950, will be increasingly brought into use during the next few years beginning, wherever practicable, with publications which include data for January 1958. Thus the averages for the new period will be used as the basis for reckoning percentage rainfall amounts in the *Monthly Weather Report* and the *Monthly Summary of the Daily Weather Report* for January 1958, and in *British Rainfall* 1958.

Tables of rainfall data supplied for publication in various monthly journals, including the *Meteorological Magazine*, will be prepared on the same basis, that is, the new period averages will be introduced with the data for January 1958. Some rainfall data, however, are supplied for eventual incorporation in year books or annual reports which refer to a 12-month period differing from the calendar year. The data in the *Surface Water Year Book* are grouped in "water years" from October to September. For this grouping of data the new period averages will be introduced for the water year 1957–58, that is, beginning with data for October 1957. Other reports are based on the financial year April to March, and it is proposed that in these cases the new period averages should be introduced for the year 1958–59, that is, beginning with data for April 1958.

In recent years there has been a growing demand for more up-to-date averages of rainfall; there has also been increasing difficulty in referring back to the earlier standard period, because of the decreasing number of rainfall stations still in existence for which observations are available for that period. Both these factors have made it necessary to change to the new period. A new book of averages, *Averages of Rainfall for Great Britain and Northern Ireland* 1916–1950, will be published during 1958, containing monthly and annual averages for 719 stations and an Introduction which includes a brief discussion of the relationships between the averages for the old period and the new. More detailed information linking the averages for the two periods, with particular relevance to applications of rainfall data, will be made available later.

A. BLEASDALE

Course on "Weather and flight"

A course on "Weather and flight" will be held under the direction of Dr. R. S. Scorer and the auspices of Birmingham University at Preston Montford Field Centre near Shrewsbury from 20–27 September 1958. The lecture programme is an attractive one ranging from "Mountain waves" to "Bird navigation" while the projected field-work programme extends from "Observing clouds by moonlight" to the "Study of air motion over obstacles using balloons and soap bubbles". The fee is £8 8*s*. including board and lodging. Application should be made as soon as possible to the Director of Extra-Mural Studies, The University, Edmund Street, Birmingham, 3, from whom further details can be obtained.

The Geophysical Journal

The Royal Astronomical Society announces the publication of a new quarterly periodical, "The Geophysical Journal", which will incorporate the former "Geophysical Supplement" to the "Monthly Notices" of the Society. The subjects which will be covered in the new periodical will be the same as those of the Geophysical Supplement, namely: geodesy, gravity measurements, seismology, oceanography, atmospheric physics, terrestrial magnetism, physics of the earth's interior, other branches of theoretical and observational geophysics and related topics in physics, mathematics and statistics.

The Society in its announcement stresses the previous lack of a regular English periodical covering such subjects as geodesy, gravity, seismology and the physics of the earth's interior.

The editors are Dr. A. H. Cook and Dr. T. F. Gaskell working in collaboration with Dr. R. A. Lyttleton, F.R.S., the Society's Geophysical Secretary. The first number published in March 1958 included papers on seismology, geomagnetism, gravity and the physics of the earth's interior by scientists in Great Britain, Australia, Canada, the United States and the Union of Soviet Socialist Republics. The price will be £3 for a volume of at least four parts. Further particulars should be obtained from the Society at Burlington House, London, W.1.

Stationary stratocumulus rolls

The values quoted for Scorer's parameter under the photograph of stationary stratocumulus rolls in the February 1958 Meteorological Magazine are of l^{-1} and "mi^{-1}" should read "mi".

REVIEWS

Dynamic meteorology and weather forecasting. By C. L. Godske, T. Bergeron, J. Bjerknes, R. C. Bundgaard. 11 in. × 8½ in., pp. xvi + 800, *illus.*, American Meteorological Society, Boston, Massachusetts, and Carnegie Institution of Washington, Washington D.C., 1957. Price: $15.

The authors of this book have international reputations as meteorologists; two of them were co-authors of *Physikalische Hydrodynamik*, to which the present book is a sequel, and Dr. Godske is well known as Professor of Meteorology at Bergen. From such authors we expect an authoritative book, both as regards theoretical and practical aspects, for they have initiated much of the research which has been carried out into dynamical meteorology and weather fore-

casting. According to V. Bjerknes's Preface the preparation of this book was commenced in 1935; during the war little communication was possible between the authors and collaboration began again in 1946 continuing to 1949–1950, when the text was completed. Another seven years elapsed before publication. During this time there was an upheaval in meteorological ideas and rapid advances made in the science. The difficulty of writing a text under these conditions must be remembered if any disappointment is felt for the book.

The book subdivided itself naturally into two parts, one on theoretical meteorology and one on the practice of meteorology. I began by reading the latter first, starting at Part IV, because it is the more difficult to write and also to find how many back-references there were, an indication of the contribution of theoretical meteorology to the forecasting problem. The chapters on general climatology and air-mass analysis are clearly written descriptive meteorology, which leave little scope for fresh presentation but which must be included in any text pretending to completeness. Frontal analysis is well presented, as we might expect from these authors, and the chapter on "Dynamical Analysis of Cyclones and Anticyclones", a rather high-sounding title, gives a clear three-dimensional picture of the atmospheric motions in frontal regions using deductions from both models and statistics. Thus illustrative matter is particularly good and the authors clearly have a feeling for the physical aspects. Tropical meteorology does not always get a mention in textbooks which are primarily concerned with extratropical weather phenomena, but there is a section here. The last chapter of Part IV deals with more local meteorological effects, such as sea-breezes and föhn winds, and also with diurnal effects. To the present reviewer Part IV seemed the most satisfactory part of the book, complete enough and with very adequate references.

Part V, which completes the book, consists of two chapters, one on synoptic weather analysis and one on weather forecasting; neither of these chapters reaches the high standard of Part IV. There are accounts of the observations which are taken and of the synoptic codes now in use. Neither of these seems suitable in a book of this character; observations are treated much more adequately elsewhere while the synoptic codes are ephemeral and one expects this book to be in use for many years. The principal example of frontal analysis—some twenty pages are allotted to it—relates to that given by Bergeron and Swoboda in 1924 and refers to the surface only. It seems a pity that the authors should have chosen to analyse a situation for which there were no upper air data, thus giving the impression that the latter do not materially aid in analysing near the surface. Subsequently, upper air analysis is described as if proceeding from a given 1000-millibar chart; one might have expected a unified treatment of the analysis of surface and upper air charts together. English students will not readily recognize the proposed technical vocabulary of upper air terms and abbreviations; these latter are carried into the text which would have been better in full even at the expense of a few extra pages. The upper air analysis itself is very well treated and even if manpower and time frequently prevent the carrying out of some of the stages, it is good to see them in print for they may be the basis of future research. Understandably the last chapter on "Weather Forecasting" is rather diffuse. Some good points are made about the distribution of observing stations and the relation between the area of analysis and that of forecasting. For the rest the authors advocate forecasting the pressure distri-

bution by extrapolation blended with experience, drawing attention to modifying effects such as orography. Who could do more? There are paragraphs on the prediction of more local phenomena but these cannot be comprehensive. There were few references to the dynamical part of the book and these were confined to formulae which had been developed under specially simple conditions. Dynamical thought in meteorology has had little impact upon the practice of forecasting, except perhaps in the last few years.

The earlier part of the book stems from *Physikalische Hydrodynamik*, of which it is a direct continuation. The chapters on thermodynamics, statics of the atmosphere and radiation are clearly written and move at a pace suitable for a student. These preliminaries to the study of dynamical meteorology are necessarily stereotyped, only lending themselves to individual treatment when more recent results are being discussed and the authors seem to write more entertainingly about newer developments, such as the Elsasser diagram, than about the older parts such as Kirchoff's Law, for example. The hundred pages devoted to the kinematics of the atmosphere have an old-fashioned appearance. There is a whole chapter devoted to vector analysis despite the many excellent texts which deal fully with this subject; there is nothing new in the presentation which is especially adapted to meteorology except a few remarks about map projection and these do not arise out of the discussion of vectors. The inclusion of non-meteorological material to be found elsewhere must increase the price of the book. The sections on kinematics of simple systems, such as the steady circular vortex, will be useful to students in that they give manipulative practice and illustrate physical concepts, for these simple systems do represent gross features of some atmospheric motions. The kinematical forecasting of the movement of troughs, ridges and other simple geometrical patterns which appear on weather maps has not proved satisfactory in practice and is now of historical interest only, hardly meriting a chapter.

Part III, "Hydrodynamics of the Atmosphere," represents the most important part of the theoretical treatment. It is conceived on the lines of the Scandinavian research and represents a summary to 1950 of that classical standpoint. The difficulty has always been the lack of theory about non-linear equations and the classical method has been the linearization of the equations by using perturbation theory. Providing that there is little interaction between motions of different scales, that is between the Fourier components of different wavelengths, the perturbation method can give fairly good results and the equations are often solvable by analytic methods. The interactions are important in meteorological phenomena. The advent of high-speed computers has made possible the integration by numerical methods of non-linear equations so that the trend of recent dynamical research has been away from the analytic solution of simplified equations towards the direct numerical solution of equations which are capable of representing the interactions of meteorological systems. The pendulum may swing again towards analytic solutions but it is unlikely that the equations will be of the same type as those considered here. This change in emphasis has taken place in the last few years and the authors are unfortunate indeed in that there was a lapse of seven years between completion of the manuscript and publication. In 1950 their review of dynamical meteorology would not have seemed out of date—in fact the reverse; to-day they seem to place emphasis on less important aspects of dynamics. Of course, much that is basic

remains unchanged. There are excellent discussions of the equations of motion, stability criteria and of the linearized equations resulting from perturbation theory; the application of these equations in Chapter 10 goes far towards explaining simple atmospheric wave motions, and later to other well known meteorological phenomena, such as waves in the lee of mountains. Finally there is an adequate chapter on turbulence.

There are many excellent features both for the student and the research worker. Each chapter is divided into sections and commences with an introduction describing briefly the contents of the chapter. Each numbered section of the chapter starts with an outline of its contents; these outlines are an excellent guide and in themselves form a short course in meteorology. At the end of each chapter is a bibliography and one has the feeling that a lead can be found into almost any meteorological problem. The book is sumptuously produced and magnificently illustrated; the line diagrams are superb (perhaps their production contributed to the delay in publication) and the coloured charts are beautiful. There is an index of some 1,500 items which, upon test, proved true; there is no name index. The symbolism looks rather strange in one or two instances—the generally recognized symbols for density and temperature are ρ and T and it is distracting to have to think in terms of other symbols.

This book is going to be a reference for many years and meteorological libraries throughout the world will have, no doubt, already bought it. The price represents about half a week's salary to a young scientist in England (perhaps one quarter for his American counterpart) and I find I am unable to offer him advice as to whether to buy or not.

E. KNIGHTING

Einführung in die Optik der Atmosphäre. By Dr. Gerhard Dietze. 9 in. × 6 in., pp. xi + 263, *illus.*, Akademische Verlagsgesellschaft Geest und Portig K.-G., Leipzig, 1957. Price: *DM* 29.

The number of books or parts of books dealing seriously with atmospheric optics is small but the quality is high. Dr. Dietze's book is worthy of its predecessors.

It is in eleven chapters (with an Appendix) which cover:

1. Introduction, units.
2. Apparent form of the sky and apparent magnification of bodies near the horizon.
3. Refraction; curvature of rays, terrestrial and astronomical refraction, mirage, looming, scintillation.
4. Haloes and associated phenomena.
5. Rainbows.
6. Coronae, glories.
7. Extinction, absorption and scattering—descriptive and instrumental.
8. The light of the sky by day and night.
9. Polarization.

10. Theories of extinction, scattering and polarization and applications to the atmosphere.

11. Visibility.

    Appendix of 9 tables, for example, spectral sensitivity of the human eye in light and dark adaptation, extinction coefficient of the Rayleigh atmosphere.

The author claims to have chosen always the method of explanation leading most surely to an understanding of the physics of the subject. This claim is fully justified. The excellent line-drawings are almost explanations by themselves.

The book calls for a knowledge of mathematics and the theory of light to about General Certificate of Education Advanced Level standard. Electromagnetic theory is not used though results derived from it have, of course, to be stated. So far as optical phenomena in the ordinary sense are concerned, haloes, mirages etc., the book is similar to but rather less mathematical than the corresponding chapters in Humphreys's *Physics of the Air*.

There are very few descriptions of actual observations of phenomena and the book would have gained in vividness if more had been included. We must turn to Pernter and Exner, Humphreys and Minnaert for them. There are five excellent reproductions of colour photographs of the 22° halo and mock suns, a sun pillar, corona, and twilight.

It is up to date, quoting the discussion on scintillation held at the Royal Meteorological Society at the end of 1954. The only omission noticed was lateral refraction, for example, from a heated wall. No novel theories are included which might help to explain the few inexplicable phenomena reported to the Meteorological Office in recent years from marine observers. There is a good index.

Dietze has not the detailed descriptions of observations of optical phenomena and the full mathematical treatment of Pernter and Exner or the charm of Minnaert. It is however up to date in those subjects, especially visibility, in which advances have been made since those classics were written and it is a model of clarity and precision in its physical explanations.

G. A. BULL

Linkes Meteorologisches Taschenbuch. Band III. (Hilfsmittel des beobachtenden Meteorologen). $8\frac{1}{4}$ in. × 6 in., pp. xvi + 441, *illus.*, Akademische Verlagsgesellschaft, Geest & Portig K.-G., Leipzig, 1957. Price: 28 *D.M.*

This, the third and last part of the new edition of the Taschenbuch, is described in the sub-title as an aid to the observing meteorologist. It is in six chapters dealing respectively with radiation, optical phenomena, atmospheric electricity, bioclimatology, "surface" meteorological instruments and, finally, aerological instruments.

The chapter on radiation, which includes visibility, is a very concise summary of physical principles with formulae and tables of the radiation balance of the Northern Hemisphere and of the *H* and *Ei* functions of transmission theory. Instruments are not dealt with except for some information on filters.

The chapter on atmospheric optics is a good survey for the observer.

Atmospheric electricity is dealt with comprehensively and practically from the instrumental point of view by Israël and Dolezalek. Instruments are described in detail with a useful section on "practical tips" for their proper working. There is a list of firms making such instruments and their components in Germany, The United Kingdom and the United States of America and a good bibliography of books and papers. Radioactivity of the earth and atmosphere and cosmic radiation are included in this chapter.

Bioclimatology is restricted to human reactions to the state of the atmosphere and radiation. The well established parts of the subject such as the heat balance of the body and reactions to radiation are described in detail and the more speculative matters of meteorotropy sketched with appropriate reservations. This is probably as good a general account of the subject as has ever been published but it is not clear why it appears in a guide for the observing meteorologist.

The chapter on surface meteorological instruments is a broad survey of the physical principles of the instruments used in measuring temperature, cooling power, pressure, humidity, precipitation, wind and aerosols. Some details of instruments used in Germany and their adjustment and calibration are included. It does not, however, give the "practical tips" the officer in charge of an observing station needs to keep his instruments in good working order.

The chapter on aerological instruments is similar to the preceding one. It includes detailed descriptions of the official German, Swiss, French, American, British (Kew), and Finnish radio-sondes and of the Mullard radar-sonde and a bibliography of 137 papers, nearly all published since 1946.

G. A. BULL

Oceanic observations of the Pacific 1949. Edited by N. W. Rakestraw, P. L. Horrer and W. S. Wooster. 11 in. × 9 in., pp. 363, *illus.*, University of California Press (agents: Cambridge University Press), 1957. Price: 34*s*. net.

In this volume, the Scripps Institution of Oceanography of the University of California has published the results of soundings at oceanographical stations in the Pacific during 1949; the observations were made by several organizations including itself. It is intended to publish a second volume containing observations made prior to 1949 and later to publish a volume for each year subsequent to 1949.

For each station, values of temperature, salinity, oxygen, phosphate, or other measured concentrations are tabulated at observed and at standard depths. Computed values of density, specific volume anomaly and geopotential anomaly are tabulated at standard depths. Charts of the station positions and positions of bathythermograph observations precede the tabulations.

The publication is well produced and will conveniently make available to the oceanographer a wealth of data for the Pacific which could hitherto only be consulted by a few.

P. R. BROWN

Solar control and shading devices. By Olgyay and Olgyay. 11 in. × 8½ in., pp. vi + 201, *illus.*, Princetown University Press, Oxford University Press, 1957. Price: £5.

If the azimuth and elevation of the sun be known, and also the intensity of the incoming solar radiation, both direct and indirect, then the extent to which a building would be shaded from radiation by other buildings, or by inbuilt "shading devices" can be computed. This book is mainly a survey of methods, for use by architects, for simplifying this computation.

In addition short chapters are devoted to a summary of the effects of temperature, humidity and air movement on comfort; and to the relative importance of direct and indirect radiation on the heat economy of a building. The chapter on comfort contains a "bioclimatic chart" which is described as for "U.S. Moderate Zone Inhabitants". The chart is markedly different, especially as regards the effect of humidity, from similar charts published in this country, and no reference is made to any British work – for example, that of L. Hill and D. Brunt. The chapter on the relative importance of direct and indirect solar radiation is pretty well limited to a discussion of a single example: that of a south facing wall in New York.

The book is well produced and lavishly illustrated by photographs and diagrams.

RONALD FRITH

Three steps to victory. By Sir Robert Watson-Watt, 9 in. × $5\frac{3}{4}$ in., pp. 480, *illus.*, Odhams Press, 96 Long Acre, London, W.C.2. 1957. Price: 30*s*.

In any history of the Second World War, two facts are beyond dispute. The first is that radar played a major part in the defeat of Hitler's plans for the subjugation of Europe. The second is that Sir Robert Watson-Watt, more than any other man, was responsible for bringing about the use of reflected radio impulses as a weapon of war, so that when the Battle of Britain was fought, this country then possessed the best radar defences in the world.

This book is the autobiography of Robert Watson-Watt, from the family home in Brechin, Scotland, to his present residence in Canada. As most of the readers of this Magazine know, Watson-Watt began his career as a professional scientist in the Meteorological Office, where he initiated work on the detection of thunderstorms (sferics). In describing this period he makes some very frank comments on the official attitude to research in meteorology in the years immediately following the First World War. One result was that radio research and Watson-Watt severed all connections with the Meteorological Office in the early twenties. In 1935, with the aid of A. F. Wilkins, he produced a memorandum, for the Committee for the Scientific Survey of Air Defence, which laid down, for the first time, the essential principles of what is now known as radar.

The remainder of this very long book is concerned with the struggle to bring the idea to the operational stage, the setting up of the early "chain" stations, the Battle of Britain, airborne radar and finally, the part played by radar in the final assault. These are matters in which not only the author, but all who worked in this field, can take legitimate pride.

The story of radar is that of a simple but extremely fruitful basic idea which was brought to final success by the skill of many scientists, backed by the determination of one "dour Scot" to see it through. As such it should not be too difficult to tell. Unfortunately, in this book the true greatness of the story is lost in a torrent of words, nearly a quarter of a million all told, of which, at a guess, a third are redundant. The style is unattractive, and the author would have

been well advised to let the facts speak for themselves, and the reader to come to his own conclusions concerning the author's repeated claim to be the "Father of Radar".

But even if the book disappoints, the story of radar cannot. Here, if ever, is the unique example of the scientific idea coming to fruition in the hour of greatest need. That we live today in freedom, and not under the yoke of a madman in Berlin, is due primarily to the men and women who fought and died in our defence. But courage is not enough—it must be backed by knowledge, and radar is an example of knowledge rightly applied and of the good that can come from single-mindedness and unshakeable belief in a cause. Those who took part in the development of radar before and during the war will discover much of interest in this book. For others it may be tedious, but everyone will find it revealing.

O. G. SUTTON

Weather record chart and calendar. By Reginald G. Cook. 14 in. × 9½ in., pp. viii + 24, *illus.*, Edward Mortimer Ltd., 12, Thayer St., London, W.1. 1958. Price: 8*s*. post free.

This extremely well printed and produced Record Chart has been devised so that almost anyone interested in the weather can keep a systematic and permanent observational record. The general arrangement is good and consists of a four-page Introduction and one ample page for each month of the year, held together with a continuous wire "lay-flat" binding and provided with a metal loop for hanging. Perhaps a firm cardboard back, so that one need not always write flat against the wall, would be a minor improvement.

The vertical rulings on each page provide for daily observations of barometric pressure, wind, temperature, rainfall and sunshine, and the reverse side of each page is ruled for a daily weather diary. Suggestions for completing the various columns are contained in the Introduction. A map showing the various divisions of the British Isles and the adjacent sea areas used in forecasts broadcast by the British Broadcasting Corporation is also included.

The introduction would be improved by the inclusion of some advice on the siting of instruments and the taking of observations. It should, for example, indicate that for the readings to be comparable even among themselves they should be taken at the same time each day necessitating change of routine during British Summer Time. Mr. Cook offers to supply normals appropriate to the observer's locality (in the United Kingdom) but these will be of little use to the observer for comparative purposes if his instruments are not reasonably well exposed. Provision is made for recording wind direction but not speed; an observer, interested enough to install an expensive sunshine recorder, would no doubt welcome a reference in the Introduction to the Beaufort Scale with specifications of equivalent wind speeds. The average number of "rain-days" and "wet-days" quoted with the monthly normals would probably be more interesting to the amateur meteorologist than the average number of hours of rain as at present given. In the reference to the Beaufort notation it seems a pity that the letter *g*, which is now understood to stand for gale in the Meteorological Office, is given its old meaning of gloom. Some observers, no doubt, would not realize that the repetition of certain of the letters neatly denotes continuity. One more suggestion: the international symbols for drizzle and

[To face p. 220.

Photograph by Betsy Woodward

WAVE CLOUD OVER SIERRA NEVADA, CALIFORNIA

Photographed from a glider at 6,500 metres, these wave clouds in lee of the Sierra Nevada show the turbulent "rotor" flow at low levels in contrast to the smooth stream aloft. With ice crystals being rather slow to evaporate, the wave cloud at cirrus tends to stream out farther downwind than the compact lenticular shaped altocumulus.

Photograph by G. Nicholson.

INTERMITTENT CONTRAIL

We are indebted to Mr. G. Nicholson, 133, Stanley Road, Teddington, Middlesex, for this photograph of an intermittent contrail. It was taken at 3.43 p.m. on 6 January 1958 at Fulwell, Middlesex, looking south-west. Mr. Nicholson saw that it was being formed in steps. He reports the trail was non-persistent, disappearing within two minutes.

[Mr. R. F. Jones comments that since the trail was non-persistent conditions for its formation were marginal. Any one of the following explanations might be the right one:

(*a*) atmospheric temperature and humidity variations,

(*b*) variation of throttle setting by the pilot,

(*c*) variation of height by the pilot who may have noticed he was making a trail and deliberately ascended and descended through the trail-forming layer.

Ed. *M.M.*]

showers, phenomena which are easily identified by the amateur, could with advantage be added to the list given.

The publishers are to be congratulated for producing a Calendar which serves such a useful purpose. It will no doubt find a ready sale to schools and farmers, and will also perhaps be found in many a private house near the beloved barometer.

R. E. BOOTH

HONOURS

The following awards were announced in the Birthday Honours List in June, 1958:

O.B.E.

D. N. Harrison, D.Phil., Principal Scientific Officer, Meteorological Office.

M.B.E.

C. E. Jowitt, Senior Experimental Officer, Meteorological Office.

METEOROLOGICAL OFFICE NEWS

Retirement.—Mr. F. G. Hawkins, Experimental Officer, retired on 31 March 1958. He joined the office from the Air Ministry in January 1924 and was posted to the British Rainfall Division. In March 1924 he was transferred to the Climatology Division where he remained until 1930 when he was posted to the Forecast Division. In 1934 he was transferred to the Instruments Division and from 1939, until his retirement, he served continuously in the Administrative Division. Mr. Hawkins served in the Royal Flying Corps, later the Royal Air Force, from 1917 to 1920.

Social activities.—In connexion with the opening of a Meteorological Office at Gatwick Airport, the Meteorological Office Staff at Croydon Airport held a farewell dinner and dance in the Croydon Terminal Building on 11 April 1958 for the staff who were to be transferred to Gatwick. The guests included members of the Air Traffic Control, Telecommunications and Customs and their friends. Mr. T. N. S. Harrower was the guest of honour. Tribute was paid to the happy relations which had always existed between the Meteorological Office staff and the Airport staff and the hope was expressed that this family spirit would be carried on at Gatwick.

Sports activities.—*Boxing.*—Mr. J. Keers, Assistant (Scientific) at London Airport won the Civil Service Light Weight Boxing Championship. In the final Mr. Keers won in the first round. This is the first time a member of the Air Ministry staff has won a Civil Service Boxing Championship.

WEATHER OF MARCH 1958

Northern Hemisphere

The main region of cyclonic activity over the North Atlantic was much further south than usual for March. On the mean monthly pressure chart the main low pressure area was situated to the north-west of the Azores at about 45°N., 40°W., where pressure was 15 millibars below normal. Associated negative pressure

anomalies occurred in a belt extending from the eastern states of the United States across the Atlantic south of 50°N., and across central and southern Europe. A small anticyclone of 1020 millibars was situated over central Scandinavia, and consequently the mean flow during the month across Europe between approximately 45°N. and 60°N. was easterly or north-easterly instead of the more normal south-westerly flow.

A large anticyclone of 1030 millibars was centred over Hudson Bay and extended over nearly all Canada and the central states of the United States. Mean pressures were above normal in this region and over all the Arctic, the maximum anomaly being +16 millibars a little north of Hudson Bay. Iceland and Spitsbergen both had pressure anomalies of +11 millibars.

The Siberian anticyclone was near normal in position, but the central pressure was 3 millibars below the normal. Over the Pacific, the Aleutian low was 5 millibars deeper than the average for March, and displaced to a position over the Kamchatka Peninsula. The North Pacific high was near normal in intensity but a little further north than usual.

Mean temperatures for the month were below average over all Europe, apart from Spain, largely as a result of the abnormal easterly flow during the month. The greatest reported anomalies were −5°C. and occurred in southern Sweden, southern Germany and Austria. Weaker flow than usual over northern Asia, allowing stagnation of the air over a snow covered surface, gave surface temperature anomalies of up to −5°C. in that region.

There were positive temperature anomalies throughout Canada, with temperatures as much as 9°C. above the average in Quebec where the usual north-westerly advection of cold air was absent. Over the United States temperatures were generally 2°C. or 3°C. below normal, although in Kansas anomalies of −5°C. occurred.

Rainfall amounts were less than normal over most parts of Scandinavia, central Europe, and the British Isles, but up to three times the normal over the Balkans. There were some unusually large totals for the month in California, but in other parts of North America amounts were generally near or below the average for March.

WEATHER OF APRIL 1958

Great Britain and Northern Ireland

April began with cold easterly winds which had been a characteristic of the last two weeks of March; winds backed to a north-easterly direction on the 6th and weather remained cold until the middle of the month, with temperature mostly below 50°F. Westerly winds and mild changeable weather prevailed during the second half of the month; temperature exceeded 70°F. during the last few days.

With high pressure over north-east Europe the air reaching the British Isles during the first three days of the month was cold and dry apart from a few snow showers in eastern districts. On Good Friday, the 4th, a depression moved into the North Sea from France and turned west across northern England, later filling as it moved southwards over the Irish Sea. The following day a second depression performed a similar rotation over southern England and northern France. These depressions were accompanied by widespread rain and snow with

strong winds in some northern districts which caused considerable drifting. The week-end was one of the coldest Easter week-ends on record and, in some areas, the wettest; at Kew, with afternoon temperature only reaching 45°F., it was the coldest Easter Saturday of the century. Settled weather was re-established on the 6th as high pressure developed to the north-west of the British Isles. From the 7th to the 12th there were scattered showers of rain and snow but sunshine was fairly plentiful, although on the 10th a small depression gave heavy rain for a time in Devon and Cornwall. On the 12th warmer air from the Atlantic reached northern Scotland and spread slowly south into northern England; temperature at Edinburgh reached 63°F. on the 14th, more than 20°F. higher than at Margate. A fresh outbreak of northerly winds brought a temporary return of cold weather to all districts on the 15th and 16th with scattered rain and sleet showers but there were long sunny periods. On the 16th Aberporth had 13·5 hours of sunshine, the highest daily total of the year so far, but thereafter weather was generally changeable and mild. From the 21st temperatures reached the sixties in many places, but it was cool along parts of the west coast, where sea fog was persistent from 19th–22nd. Rain was fairly widespread from 24th–26th. For the last two days of the month a warm anticyclone covered much of the country giving sunny weather generally with temperatures of over 70°F. locally; 75°F. was reached at Hampton, Middlesex.

Over the month as a whole temperature was mostly below average except in northern Scotland. In most places the warmer weather of the latter half of the month failed to compensate for the cold of the first two weeks when temperature locally was as much as 7°F. below the April normal. Rainfall was 52 per cent of the average in England and Wales and 75 per cent in Scotland, where, following the spell of dry April months, it was the wettest April since 1953. Sunshine was about average in most places but slightly below in the south-west.

The long cold spell at the beginning of the month delayed most crops and reports of frost damage to salad crops, cabbage and early potatoes came from many districts. Top fruit also was behind, but it was hoped that the delayed flowering might give some chance of escape from late frosts. The warmer weather at the end of the month brought very rapid growth, especially in the stages of fruit blossoming.

WEATHER OF MAY 1958

Great Britain and Northern Ireland

The general character of the weather is shown by the following provisional figures:—

	AIR TEMPERATURE			RAINFALL		SUNSHINE
	Highest	Lowest	Difference from average daily mean†	Percentage of average*	No. of days difference from average*	Percentage of average†
	°F.	°F.	°F.	%		%
England and Wales ...	80	25	0·0	133	+5	94
Scotland	75	19	−1·3	132	+3	108
Northern Ireland ...	71	29	−1·5	108	+1	103

* 1916-1950 † 1921-1950

RAINFALL OF MAY 1958

Great Britain and Northern Ireland

County	Station	In.	*Per cent of Av.	County	Station	In.	*Per cent of Av.
London	Camden Square	2·25	127	*Carm.*	Pontcrynfe	5·09	143
Kent	Dover	2·20	126	*Pemb.*	Maenclochog, Dolwen Br.	5·82	165
,,	Edenbridge, Falconhurst	1·84	86	*Radnor*	Llandrindod Wells	2·79	103
Sussex	Compton, Compton Ho.	3·38	137	*Mont.*	Lake Vyrnwy	6·54	179
,,	Worthing, Beach Ho. Pk.	2·60	158	*Mer.*	Blaenau Festiniog	9·55	150
Hants	St. Catherine's L'thouse	2·80	152	,,	Aberdovey	3·80	130
,,	Southampton, East Pk.	2·15	106	*Carn.*	Llandudno	2·37	115
,,	South Farnborough	2·16	113	*Angl.*	Llanerchymedd	4·59	170
Herts.	Harpenden, Rothamsted	1·98	96	*I. Man*	Douglas, Borough Cem.	3·35	116
Bucks.	Slough, Upton	2·44	124	*Wigtown*	Newtown Stewart	2·76	92
Oxford	Oxford, Radcliffe	2·13	105	*Dumf.*	Dumfries, Crichton R.I.	3·88	142
N'hants.	Wellingboro' Swanspool	2·12	105	,,	Eskdalemuir Obsy.	4·34	115
Essex	Southend W.W.	1·75	112	*Roxb.*	Crailing	2·43	121
Suffolk	Ipswich, Belstead Hall	2·35	142	*Peebles*	Stobo Castle	2·47	95
,,	Lowestoft Sec. School	2·82	189	*Berwick*	Marchmont House	2·73	124
,,	Bury St. Ed., Westley H.	2·24	121	*E. Loth.*	N. Berwick	1·96	93
Norfolk	Sandringham Ho. Gdns.	3·31	161	*Midl'n.*	Edinburgh, Blackf'd H.	1·97	89
Dorset	Creech Grange	2·54	109	*Lanark*	Hamilton W.W., T'nhill	2·76	105
,,	Beaminster, East St.	3·61	138	*Ayr*	Prestwick	2·59	116
Devon	Teignmouth, Den Gdns.	2·68	118	,,	Glen Afton, Ayr. San	3·54	105
,,	Ilfracombe	3·20	142	*Renfrew*	Greenock, Prospect Hill	4·50	125
,,	Princetown	8·19	167	*Bute*	Rothesay, Ardencraig	3·71	106
Cornwall	Bude	2·55	121	*Argyll*	Morven, Drimnin	3·38	101
,,	Penzance	3·22	132	,,	Poltalloch	2·95	85
,,	St. Austell	5·13	168	,,	Inveraray Castle	6·16	132
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Leics.	Thornton Reservoir	1·78	78	*Aberd.*	Braemar	...	...
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